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ATMOSPHERIC ENVIRONMENT FOR SATURN (SA-5) FLIGHT TEST

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NASA

George C. Marshall Space Flight Center, Huntsville, Alabama

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ABSTRACT

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An evaluation of atmospheric conditions during the flight test of Saturn (SA-5) on January 29, 1964, is presented. The general synoptic situation for the flight area is discussed, surface observations are presented, and upper air data, measured near launch time by rawinsonde and rocketsonde observation, are given. Wind and thermodynamic data are presented graphically and compared to the Patrick Air Force Base reference atmosphere. Atmospheric effects on the performance of Saturn (SA-5) are listed.

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AERO-ASTROPHYSICS OFFICE
AERO-ASTRODYNAMICS LABORATORY
RESEARCH AND DEVELOPMENT OPERATIONS

ACKNOWLEDGEMENTS

The acoustic analysis for this report was made by Mr. D. G. McBryde, and the vehicle measured wind data provided by the Flight Evaluation Branch, Aero-Astrodynamics Laboratory. Much of the tabular data was compiled by the Data Reduction Branch, Computation Division, under the direction of Mr. Paul R. Harness.

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DEFINITION OF SYMBOLS

SYMBOL	DEFINITION
C	Degree Celsius
K	Degree Kelvin (Absolute)
db	Decibel - a unit for measuring the volume of a sound, equal to the logarithm of the ratio of the intensity of the sound to the intensity of an arbitrarily chosen standard sound, i.e. 0.0002 microbar.
kp	Kilopond - kilogram force
km	Kilometer
m	Meter
mb	Millibar
m/sec or m/s	Meters per second
n	Refractive Index
rms	Root mean square
T-time or T-0	Vehicle launch time
W_x	Range direction wind component relative to vehicle flight path (105 degrees east of true north), head to tail positive.
W_z	Cross-range wind component relative to vehicle flight path (105 degrees east of true north), left to right positive.
Z-time	Greenwich civil time

UNUSUAL TERMS

Scattered clouds	0.1 through 0.5 sky cover
Broken clouds	0.6 through 0.9 sky cover
Wind shear	The wind velocity difference over some height interval divided by that interval
Normal	The Patrick Air Force Base (PAFB) Reference Atmosphere (Ref. 1) is defined as normal for the Cape Kennedy (Canaveral) area.
High dynamic pressure region	This varies with vehicle speed and air density and usually occurs between 8 and 16 km altitude.
ARDC	The ARDC Model Atmosphere, 1959

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ATMOSPHERIC ENVIRONMENT FOR SATURN (SA-5) FLIGHT TEST

SUMMARY

The observed winds were very close to the December median wind profile for the pitch plane, which was used to bias the tilt program, resulting in small angles of attack in the pitch plane. Winds averaged about 10 m/s in the first 5 km and they backed from the northeast at the surface to west-northwest at 5 km altitude. Winds were westerly in the high dynamic pressure region and reached a peak of 42 m/s from 268^{o} at 11 km (69 sec flight time). This is less than the high dynamic pressure region winds experienced by SA-1 or SA-4. However, the peak pitch plane shear of 0.0162 sec^{-1} (1000 m interval) experienced at 10 km was slightly stronger than any pitch plane shear experienced by previous Saturn vehicles.

Temperature was more than 2-standard deviations below normal and density was more than 2-standard deviations above normal at 1 km. In the high dynamic pressure region, temperature was almost 2-standard deviations above normal while density was well below normal. Pressure was 2-standard deviations above normal at the surface and it continued normal or above to 22 km. Relative humidity was unusually low from 2 to 3 km, but it was above normal from 6 to 13 km. The refractive index was unusually low in the first 2 km.

At launch time, a ridge of high pressure, accompanied by fair weather, covered the eastern United States, including the launch area. There were no fronts, jet streams or precipitation near the launch area. Scattered cirrus (high thin ice-crystal clouds) and cumuliform clouds were observed in the launch area, but they did not obscure the flight path during the Saturn (SA-5) flight test.

SECTION I. INTRODUCTION

An evaluation of the atmospheric environment for the Saturn (SA-5) flight test is presented. Saturn (SA-5) was launched from Cape Kennedy, Florida, on a bearing of 105 degrees east of north at 1625Z, January 29, 1964. In addition to the complete vehicle system performance test, a live S-IV stage was tested, for the first time in flight, and inserted into an earth orbit. The eight-engine tilt program was biased for the December median wind profile, essentially a tail wind reaching a maximum speed of 40 m/s in the high dynamic pressure region (Ref. 11).

The general weather situation for the flight area is described, and surface and upper air observations are given. Wind and thermodynamic data are presented graphically to permit ready comparison with similar data for other flight tests at the Atlantic Missile Range. This paper is the 33rd and last of the series of atmospheric summaries which document each vehicle flight test made by this organization since Jupiter-15 was tested on October 13, 1959 (See Table I). Future atmospheric summaries will be added to the reports of the Saturn Flight Evaluation Working Group as appendices. Detail atmospheric data records are maintained by the Aero-Astrophysics Office, Terrestrial Environment Group, for all test flights.

SECTION II. DISCUSSION

A. SOURCES OF DATA

The description of the general synoptic situation at launch time is taken from weather maps made by the U. S. Weather Bureau and/or Patrick Air Force Base Weather Station, plus all available observations from the launch area. Surface and upper air observations were made at the Cape Kennedy launch site under the supervision of the U. S. Air Force Missile Test Center. Wind measurements were made on board the space vehicle as described by Hagood (Ref. 2). High altitude winds and thermodynamic data were measured by rocketsonde as described by Smith (Ref. 3) and Quiroz, et al. (Ref. 4).

B. METHODS OF MEASUREMENT AND COMPUTATION

Details of measurement systems and methods of computation may be found in Reference 5.

C. GENERAL SYNOPTIC SITUATION AT VEHICLE LAUNCH TIME

1. Pressure Distribution and Fronts. A ridge of high pressure, centered near Chattanooga, Tennessee, at launch time, covered the eastern United States including the launch area (Fig. 1). Surface pressures exceeded 1.05235 kg/cm^2 (1032 mb) over much of the southeast. There were no fronts between Cuba and the Great Lakes. At 500 mb (6 km altitude), the center of the high pressure ridge was south of Cuba, a trough of low pressure extended from north of the Great Lakes to New Mexico, and westerly winds prevailed across the launch area (Fig. 2).

2. Associated Weather and Jet Streams. Scattered cirrus (a thin ice-crystal type cloud), and scattered to occasionally broken cumuliform clouds, based near 1100 m, were reported from Florida to the Bahamas. Scattered clouds were observed along the flight path of Saturn (SA-5), but no precipitation was reported in the launch area. Surface winds were 5 to 7 m/s from the northeast throughout the launch area. Seasonally normal winds prevailed at all levels. The nearest jetstream moved from west to east across central Alabama and Georgia with speeds above 50 m/s (Fig. 3).

D. SURFACE OBSERVATIONS NEAREST SA-5 LAUNCH TIME

1. Tabular Surface Observation Data

PLACE	LAUNCH TIME ± min	PRESS kg/cm^2	TEMP °C	REL HUM %	VSBY km	WIND DIR deg	WIND SPD m/s	SKY COVER AMT Tenths	SKY COVER TYPE --	SKY COVER BASE ht(m)
Service Structure (35 m)	T-0	1.04368*	16.4*	52*	-	-	-	-	-	-
Service Structure (73 m)	T-0	1.03812*	16.4*	46*	-	-	-	-	-	-
Rawinsonde Station (Cape)	T+2	1.04807 (1027.8mb)	17.8	59	16	50	6.2	2 4	Cirrus Strato-Cumulus	Unk 1100
Patrick AF Base	T-25	1.04807	17.8	58	19	40	6.7	Sctd Sctd	- -	High 900
Patrick AF Base	T+35	1.04807	18.3	54	19	50	7.2	Sctd Sctd	- -	High 900
Grand Bahama Island	T-0	1.04633	20.6	50	16	40	8.2	1 2	Cirrus Cumulus	Unk 1100
Grand Bahama Island	T+15	1.04593	20.6	50	16	40	7.7	1 2	Cirrus Cumulus	Unk 1100

* Data from self-recording instruments; calibration uncertain

2. Aerovane Wind Records. Several wind measurements near the SA-5 launch pad were made by aerovanes, an accurate wind sensing system. The three aerovane records least affected by environmental shielding are shown in Figure 4. They display a typical increase of wind speed with altitude. The highest aerovane on the service structure was 108 m MSL and 297 m northwest of the launch pad at T-0. At launch time it showed a wind of 12 m/s from 47^{o}. No effects from the launch blast can be seen on this record. The umbilical tower aerovane showed the greatest disturbance from the launch blast. This aerovane was 69 m MSL and only 23 m northeast of the launch pad. At T-0 a wind of 10 m/s from 10^{o} was recorded by this aerovane. Starting about 5 sec after T-0, the launch blast shifted the wind to 330^{o} and then back to 30^{o} before returning to prelaunch conditions. At the same time the wind speed increased from 10 to 12 m/s, dropped to 7 m/s and then rose to 12 m/s again before returning to prelaunch conditions. The pad light pole aerovane, at 24 m MSL, was 70 m northeast of the launch pad. At T-0 this aerovane measured a wind of 9 m/s from 38^{o}. Shortly after T-0 the wind shifted to 30^{o} and dropped 1 m/s. This may or may not have been due to the launch blast.

E. TIME AND SPACE VARIATIONS BETWEEN VEHICLE FLIGHT PATH AND UPPER AIR MEASUREMENTS BY RAWINSONDE AND ROCKETSONDE

1. Rawinsonde Path. Two minutes after T-0, a rawinsonde balloon was released 6.5 km south of the launch pad to measure wind and thermodynamic data. The wind first carried the rawinsonde to the southwest, then south, southeast and finally eastward to a point 70 km east-southeast of the SA-5 launch point where the balloon burst, 82 minutes after T-0, thus ending the observation. At that time it was 47 km east-southeast of the position reached by SA-5 when SA-5 was at the altitude where the balloon burst (See Fig. 5).

2. Rocketsonde Path. One hour and 46 minutes after T-0, a meteorological rocket was fired in an easterly direction. The target (parachute) was acquired 49 km east-by-north from the SA-5 launch pad at 56 km altitude. The wind data from this observation are not considered reliable above 51 km, but thermodynamic data appear to be valid from 55 to 25 km. During the 17 minutes the rocketsonde target was under observation, it drifted 21 km to the east-northeast while dropping to 25 km altitude where the observation ended. At that time it was 56 km east-northeast of the position reached by SA-5 when SA-5 was at the same altitude.

F. WIND DATA

1. Wind Speed and Direction. Northeast surface winds of 5 to 7 m/s were reported in the launch area at T-0. Higher up on the SA-5 vehicle, aerovanes showed north-northeast winds near 10 m/s (Fig. 4). With increasing altitude, the winds backed through north to west and increased to a maximum velocity of 42 m/s from the west in the high dynamic pressure region (Fig. 6-7). This is about 10 m/s less than the high dynamic pressure region winds for SA-4 (Fig. 8). Light variable winds, averaging about 7 m/s, were reported in the 20 to 30 km region, above which the winds shifted to the west and southwest and increased to 30 to 40 m/s in the 30-40 km region. Rawinsonde and vehicle wind measurements show good agreement up to about 32 km. Vehicle wind measurements are unreliable at higher altitudes due to low dynamic pressure.

2. Wind Components. Northeast winds were encountered during the first 2 km of flight. Range wind components came from the rear between 2 and 20 km altitude, reaching a peak of 41 m/s at 11 km (Fig. 9). This is very close to the December median range wind profile (Ref. 6) which was used to bias the tilt program, and it is 5 m/s less than the maximum tail wind experienced by SA-4 (Fig. 10). Cross-range wind components were from the left up to 7 km, with a 10 m/s maximum at 2 km. Between 7 and 20 km, winds were from the right with a peak cross-range component of 11.5 m/s at 10 km (18 m/s by vehicle wind measurement). This is only half as strong as the rawinsonde measured winds in the high dynamic pressure region from the right experienced by SA-4. Rocketsonde wind measurements above 30 km show tailwind components of more than 30 m/s, accompanied by cross-range components of about 20 m/s from the right. A table which lists the extreme winds and wind components in the high dynamic pressure region for all Saturn vehicles is shown below. For further details of wind speed, direction and components see Figures 6-10.

MAXIMUM WIND SPEED (RAWINSONDE) IN HIGH DYNAMIC PRESSURE REGION

Saturn Vehicle	Maximum Wind			Maximum Wind Components			
	Speed (m/s)	Dir (deg)	Alt (km)	Pitch (W_x) (m/s)	Alt (km)	Yaw(W_z) (m/s)	Alt (km)
SA-1	47.0	242	12.25	36.8	13.00	-29.2	12.25
SA-2	33.6	261	13.50	31.8	13.50	-13.3	12.25
SA-3	31.3	269	13.75	30.7	13.75	-11.3	12.00
SA-4	51.8	253	13.00	46.2	13.00	-23.4	13.00
SA-5	42.1	268	10.75	41.1	10.75	-11.5	11.25

3. <u>Wind Shear</u>. The wind shear shown herein is the absolute shear value, that is, the modulus of the shear. Wind shears computed over 1000 m intervals are shown in Figure 11. The extreme pitch plane wind shear in the high dynamic pressure region for SA-5 was 0.0162 per sec at 17 km altitude. This is a little higher than any 1000 m interval shear in the high dynamic pressure zone experienced by any previous Saturn vehicle. Cross-range shears were considerably less than for SA-3 or SA-4. Rawinsonde measured shears computed over the 1000 m interval are recommended in preference to smaller interval shears because of their greater accuracy. A table comparing extreme shear values in the high dynamic pressure region, for all Saturn vehicles to date, is shown below.

EXTREME WIND SHEAR (RAWINSONDE) IN HIGH DYNAMIC PRESSURE REGION

Saturn Vehicle	1000 m interval				500 m interval				250 m interval			
	Pitch Plane sec^{-1}	Alt km	Yaw Plane sec^{-1}	Alt km	Pitch Plane sec^{-1}	Alt km	Yaw Plane sec^{-1}	Alt km	Pitch Plane sec^{-1}	Alt km	Yaw Plane sec^{-1}	Alt km
SA-1	------	--	------	--	0.0221	12	0.0266	16	0.0415	15	0.0350	16
SA-2	0.0144	15	0.0083	16	0.0196	14	0.0145	12	0.0261	14	0.0196	12
SA-3	0.0105	14	0.0157	13	0.0155	15	0.0182	13	0.0355	14	0.0205	13
SA-4	0.0155	13	0.0144	11	0.0231	13	0.0194	13	0.0326	13	0.0313	13
SA-5	0.0162	17	0.0086	10	0.0201	15	0.0225	10	0.0289	17	0.0374	10

---Data not computed

4. <u>Time Comparison With Prelaunch Wind Data</u>. Wind direction and speed, measured by rawinsonde observations 6, 11 and 16 hours prior to launch are compared graphically with the T-0 winds in Figures 12 and 13. Through the first 20 km, for the most part, it can be seen that the wind veers and weakens with time. This is a logical sequence for the winds from a weakening high pressure area drifting eastward as shown in Figure 1. The erratic changes in wind direction in the low wind speed zone between 20 and 30 km altitude is a common diurnal type change which may be due to tidal effects in the higher atmosphere. An investigation of diurnal wind changes in this layer should be of value for theoretical studies.

G. THERMODYNAMIC DATA FROM RAWINSONDE AND ROCKETSONDE MEASUREMENTS

1. Type of Measurement and Presentation. Thermodynamic data were measured from the surface to 30 km altitude with a rawinsonde which was released at T + 2 minutes. Thermodynamic measurements were extended to 54 km about 2 hours later by means of a meteorological rocket. Temperature, density, pressure, and index of refraction, from the surface to 54 km altitude, are compared graphically to the PAFB Reference Atmosphere in Figures 14, 15 and 16. The 2-standard deviation limits are also shown for temperature, density and pressure.

2. Temperature. Temperature ranged from 18 C at the surface to a low of -73 C (200 K) at 17 km, after which it increased to 6 C (uncorrected) at 45 km (See Figure 16). Rocketsonde thermistor calibration is uncertain at this altitude, but the true temperature was probably about 2 C by the correction factors used by Quiroz (Ref. 4). Temperature was more than 2-standard deviations below normal at 1 km, almost 2-standard deviations above normal in the high dynamic pressure region and near 2-standard deviations below normal from 18 to 22 km.

3. Density. Density at the surface was 1.2233 kg/m^3 which is about 3 percent above normal. At 1 km, density was more than 2-standard deviations above normal. In the high dynamic pressure zone density was about 2-percent below normal. For further details of density, see Figure 14.

4. Pressure. The surface pressure of 1.04807 kg/cm^2 (1027.8 mb) was 2-standard deviations above normal. Pressure continued normal or above through the high dynamic pressure region to 22 km. After falling slightly below normal, from 22 to 31 km altitude, it went above normal from 31 to 54 km (Fig. 15) becoming 5 percent greater than normal at 48 km.

5. Relative Humidity. Relative humidity was near normal in the lower levels, but fell off sharply above 1 km (Fig. 17). Above 6 km altitude, humidity was higher than normal.

6. Index of Refraction. The index of refraction was unusually low in the first 2 km, but returned to normal at 5 km altitude, as shown in Figure 15.

7. Low-Level Thermodynamic Data. Thermodynamic values sometimes vary sharply over a short vertical distance near the surface of the earth and vehicles of the Saturn-Nova class are tall enough to extend through a considerable range of thermodynamic values while sitting on the pad. Figure 18 has been constructed on an expanded scale to show

the thermodynamic values along the length of the Saturn (SA-5) vehicle at launch time. From Figure 18, it can be seen that in this particular case temperature was almost isothermal for the length of the SA-5 vehicle.

H. FAR-FIELD ACOUSTICAL ANALYSIS

The T-0 rawinsonde measurements were used to make an analysis of sound propagation in the area surrounding the SA-5 launch site. The method of ray tracing described by Mabry [7] was used to locate the areas where rays returned to the earth's surface. Theoretical calculations of the acoustic intensity levels were accomplished by using equations developed by Heybey [8]. Theoretical acoustical intensity levels can be calculated only in the areas where rays are returning. The intensity level equations assume a static sound source at ground level, and therefore the intensity levels are representative only during the time interval between ignition and lift off of the vehicle. Further analytical work is needed in order to extend the technique so that intensity levels may be calculated under condition of a moving sound source. It is already known that the sound propagation, and thus the sound intensity levels, generated by vehicles in flight is considerably different from that of a stationary sound source. At present, there are no terrain, attenuation or directivity terms in the intensity level equations. An acoustic power level of 208 db was used for the vehicle in these calculations.

Velocity-of-sound profiles for 194°, 220°, and 294° azimuths are shown in Figure 19. A comparison of the calculated intensity levels with the measured sound pressure levels obtained from Wilkinson (Ref. 9) is shown in Figure 20. The area in the first five or six kilometers from the launch site where rays return shows a close agreement between the calculated sound intensity levels and the measured sound pressure levels. In the southeast quadrant, over the ocean, an area between 20 and 30 kilometers distant had rays returning, but no sound pressure measurements were made there. No anomalous sound intensity levels were detected, over land areas, while the vehicle was still on the launch pad.

The far-field sound pressure level measurements for SA-5 launch were not significantly different (within errors of the measurements) from previous flight tests of the Saturn, even though the SA-5 engines were fired at full thrust. A comparison with previous Saturn tests is difficult to make, due to changes in the location of launch and sound pressure level measuring sites.

I. ATMOSPHERIC EFFECTS NOTED ON THE PERFORMANCE OF SATURN (SA-5)

The following remarks were taken from Ref. 10, or were supplied by contributors to Reference 10:

The optimum launch window for capsule recovery was from 3 hours after sunrise to 3 hours before sunset. Daylight and minimum cloud coverage were required for ground camera coverage.

Prelaunch fuel temperature was 8-11° C below previous flights. (Ambient temperatures were 5 to 10° C below previous test temperatures.) A high specific fuel weight resulted, and new fuel and LOX tanking weights were specified and corrections made.

Mach number and dynamic pressure were very close to predicted values.

Lateral deviation was attributed primarily to thrust vector misalignments (not to wind).

The actual mean wind was very close to the 50 percent zonal December wind used to bias the tilting program and resulted in small pitch angles of attack. The maximum actuator deflection of -1.2 degrees in pitch occurred at 74.9 seconds as a result of an 8 m/s wind gust. The greatest deviation from the wind profile used in designing the tilt program and the wind encountered during flight (11 m/s) occurred at this time and contributed to the maximum actuator deflection. Yaw deviations were larger than pitch deviations even though the yaw plane wind component was much smaller. This was the expected result of biasing the tilt program to reduce the pitch angle of attack. Angles of attack were small throughout flight with the maximum of -2.4 degrees occurring at 66.3 seconds. This was also the time the maximum wind velocity (18 m/s by angle of attack) in the yaw plane was reached.

A comparison of the total angle of attack and actuator deflections with the design values for the Saturn I vehicle was made. The design values were determined from 95 percent (steady state) non-directional winds and (associated 99 percentile shears and wind gusts).* Also 2σ aerodynamic thrust and mass variations were used. During the maximum dynamic pressure region, the vehicle was well below the design angle of attack.

Components of wind velocity obtained using these (angle of attack) measurements are in good agreement with rawinsonde components. However, this agreement was obtained by assuming that the Q-ball indicator was misaligned 0.28 deg in pitch and 0.33 deg in yaw to the aerodynamic center line.

*(steady state) and (associated 99 percentile shears and wind gusts) inserted by Editor.

A substance coated the capsule windows on the externally viewing cameras and obscured most of the coverage prior to and during separation. (This substance had the appearance of and behaved much like ice, but the computed temperatures were too high for icing. Also, it occurred above the normal icing level. This problem is being investigated. A nitrogen purge has been designed to prevent camera window coating on subsequent vehicles).

TABLE I

PREVIOUSLY PUBLISHED ATMOSPHERIC ENVIRONMENT SUMMARIES

Sequence No.	Missile	Report No.	Date
1	Jupiter 15	ABMA-DA-TR-65-59	Oct. 13, 1959
2	Jupiter 19-B (JUNO II)	ABMA-DA-TR-69-59	Nov. 4, 1959
3	Jupiter 19	ABMA-DA-TR-71-59	Dec. 14, 1959
4	Jupiter 33	ABMA-DA-TR-1-60	Jan. 6, 1960
5	Jupiter 31	ABMA-DA-TR-5-60	Jan. 29, 1960
6	Jupiter 25	ABMA-DA-TM-16-60	Feb. 5, 1960
7	Jupiter 19-A (JUNO II)	ABMA-DA-TM-17-60	Feb. 18, 1960
8	Jupiter 24	ABMA-DA-TM-24-60	Feb. 25, 1960
9	Jupiter 32	ABMA-DA-TM-25-60	Jul. 17, 1960
10	Jupiter 30	ABMA-RG-TM-2-60	Aug. 1, 1960
11	Pershing 108	ABMA-RG-TM-4-60 (appendix)	Aug. 5, 1960
12	Jupiter 26	ABMA-RR-TM-2-60	Aug. 29, 1960
13	Jupiter 28	ABMA-RR-TM-3-60	Aug. 29, 1960
14	Pershing 109	ABMA-RG-TM-7-60 (appendix)	Sep. 29, 1960
15	Pershing 110	ABMA-RG-TM-21-60 (appendix)	Nov. 8, 1960
16, 17, 18	Pershing 105, 106, 107	ABMA-RG-TM-17-60	Nov. 14, 1960
19	Jupiter 19-C (JUNO II)	MSFC-MTP-AERO-60-11	Dec. 12, 1960
20	Jupiter 19-D (JUNO II)	MSFC-MTP-AERO-60-24	Dec. 30, 1960
21	Mercury-Redstone 1A	MSFC-MTP-AERO-61-10	Feb. 24, 1960
22	Mercury-Redstone 2	MSFC-STR-M-61-7	Mar. 25, 1960
23	Jupiter 19-F (JUNO II)	MSFC-MTP-AERO-61-41	Apr. 10, 1961
24	Mercury-Redstone BD	MSFC-MTP-AERO-61-51	May 1, 1961
25	Jupiter 19-E (JUNO II)	MSFC-MTP-AERO-61-55	June 30, 1961
26	Mercury-Redstone 3	MSFC-MTP-AERO-61-59	July 20, 1961
27	Jupiter 19-G (JUNO II)	MSFC-MTP-AERO-61-60	Aug. 1, 1961
28	Mercury-Redstone 4	MSFC-MTP-AERO-61-74	Sep. 28, 1961
29	Saturn (SA-1)	MSFC-MTP-AERO-61-92	Dec. 18, 1961
30	Saturn (SA-2)	MSFC-MTP-AERO-62-57	July 10, 1962
31	Saturn (SA-3)	MSFC-MTP-AERO-63-20	Mar. 15, 1963
32	Saturn (SA-4)	MSFC-MTP-AERO-63-61	Aug. 20, 1963

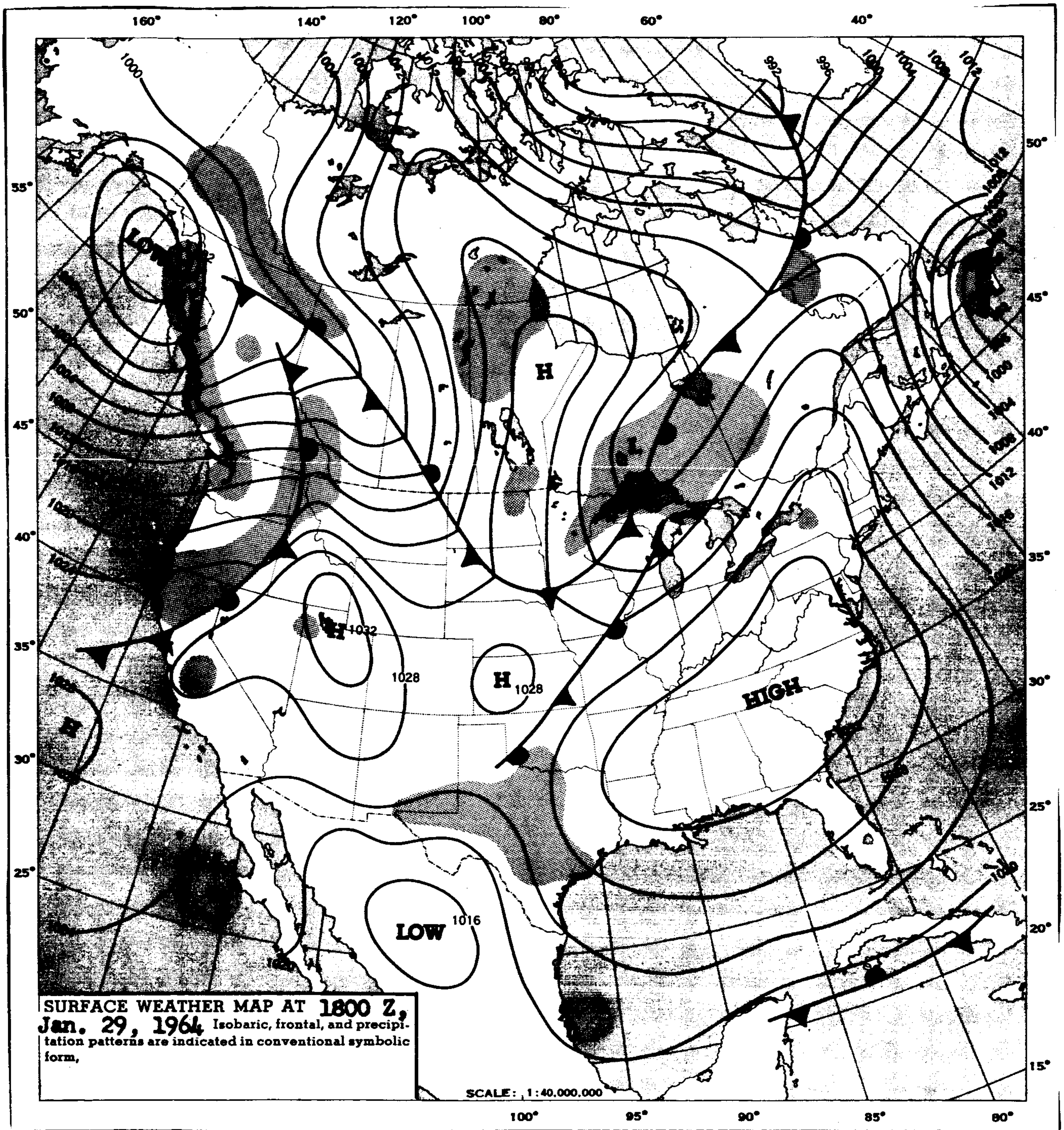


FIGURE 1. SURFACE WEATHER MAP $1\frac{1}{2}$ HOURS AFTER LAUNCH

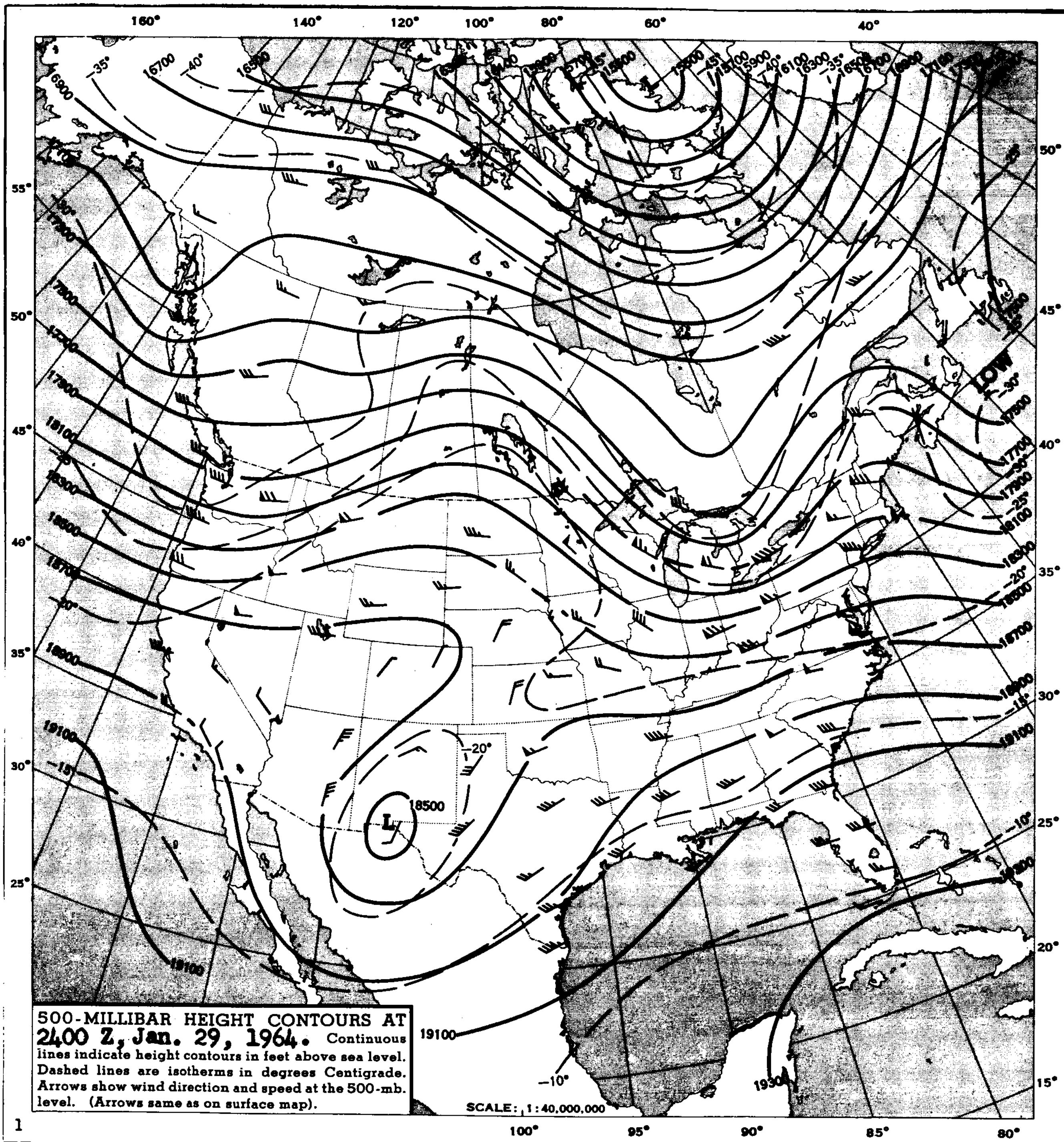


FIGURE 2. 500 MILLIBAR CHART 8 HOURS AFTER LAUNCH

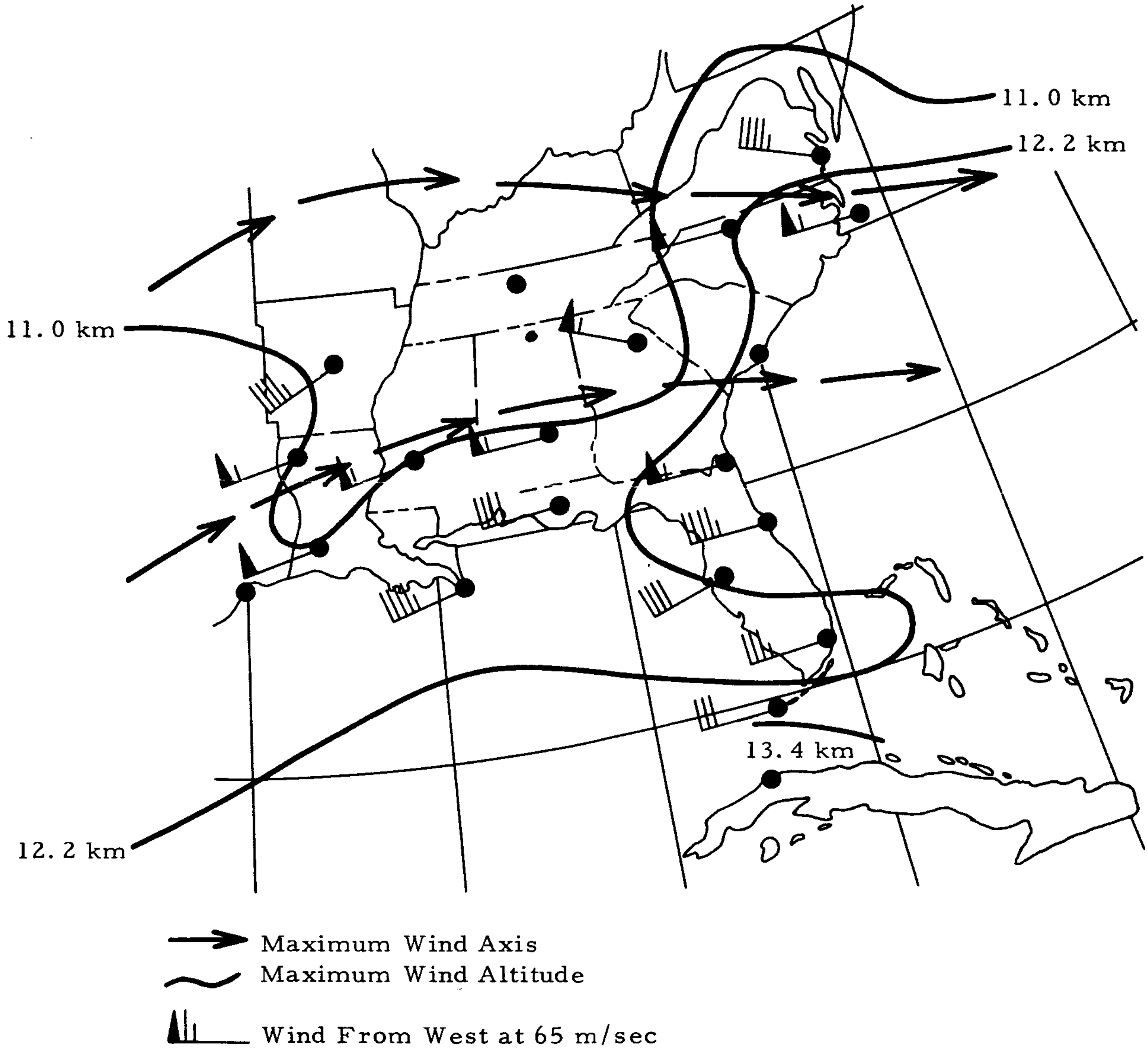


FIGURE 3. MAXIMUM WIND CHART (TROPOSPHERE) FOR SA-5 AT 1200 GMT, JANUARY 29, 1964

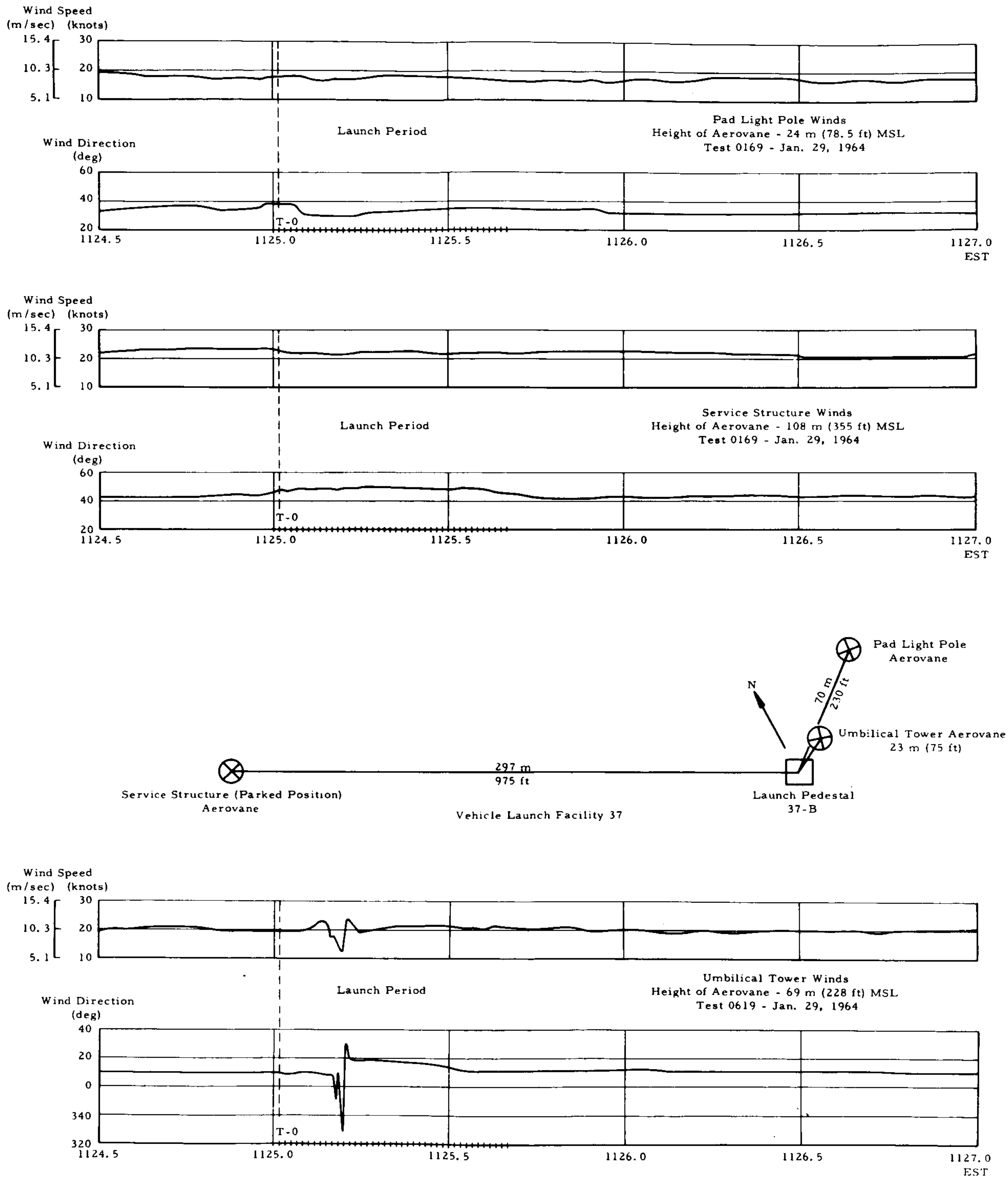
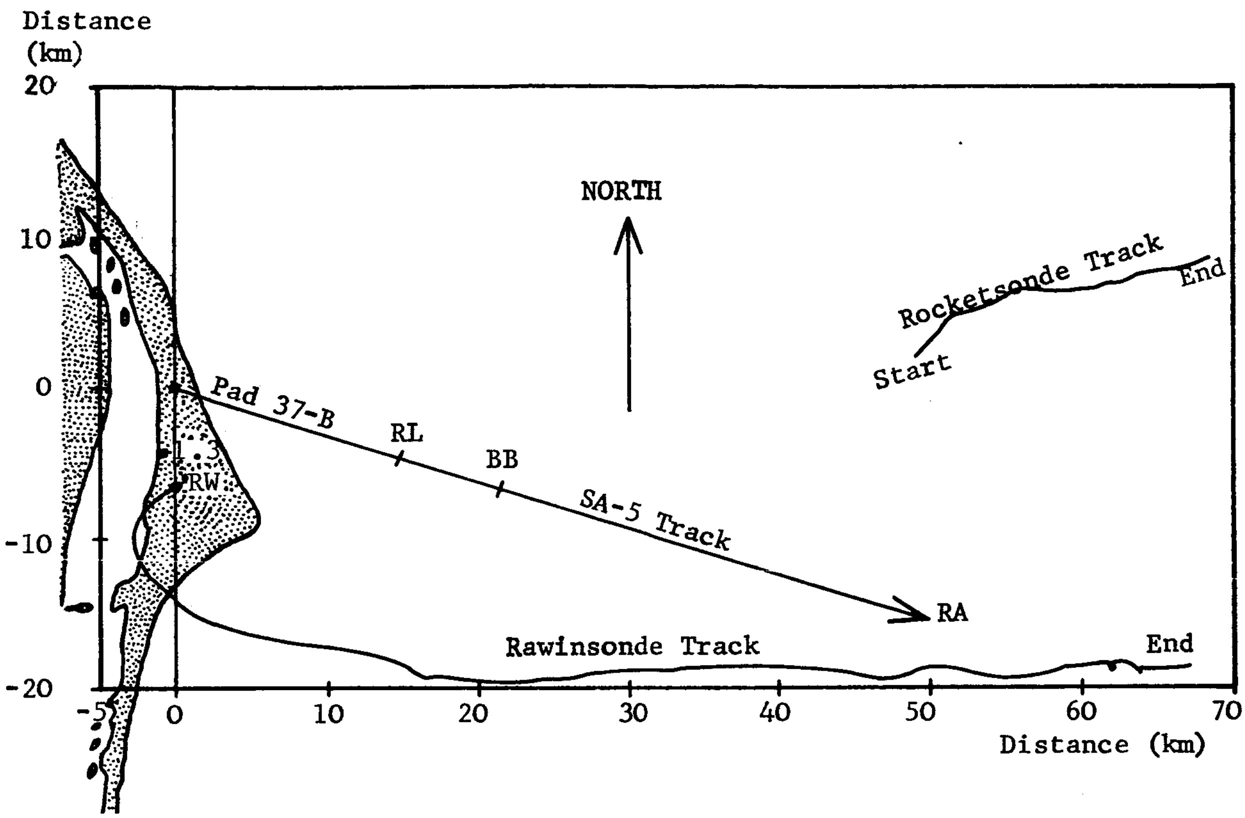


FIGURE 4. SATURN (SA-5) LAUNCH SITE WIND (AEROVANE) MEASUREMENTS



Pad 37-B - SA-5 launch point

RW - Point where rawinsonde was launched 2 minutes after T-0.

BB - Ground projection of the SA-5 position when it was at the same altitude where the rawinsonde balloon burst, 1 hour and 22 minutes after T-0.

RL - Ground projection of SA-5 position when it was at the altitude where the rocketsonde wind sensor was lost.

RA - Ground projection of the SA-5 position when it was at the altitude where the rocketsonde wind sensor was acquired 1 hour and 46 minutes after T-0.

1.3 - Rocketsonde radar

FIGURE 5. THE RAWINSONDE, ROCKETSONDE AND SATURN (SA-5) TRAJECTORIES PROJECTED ON A HORIZONTAL PLANE

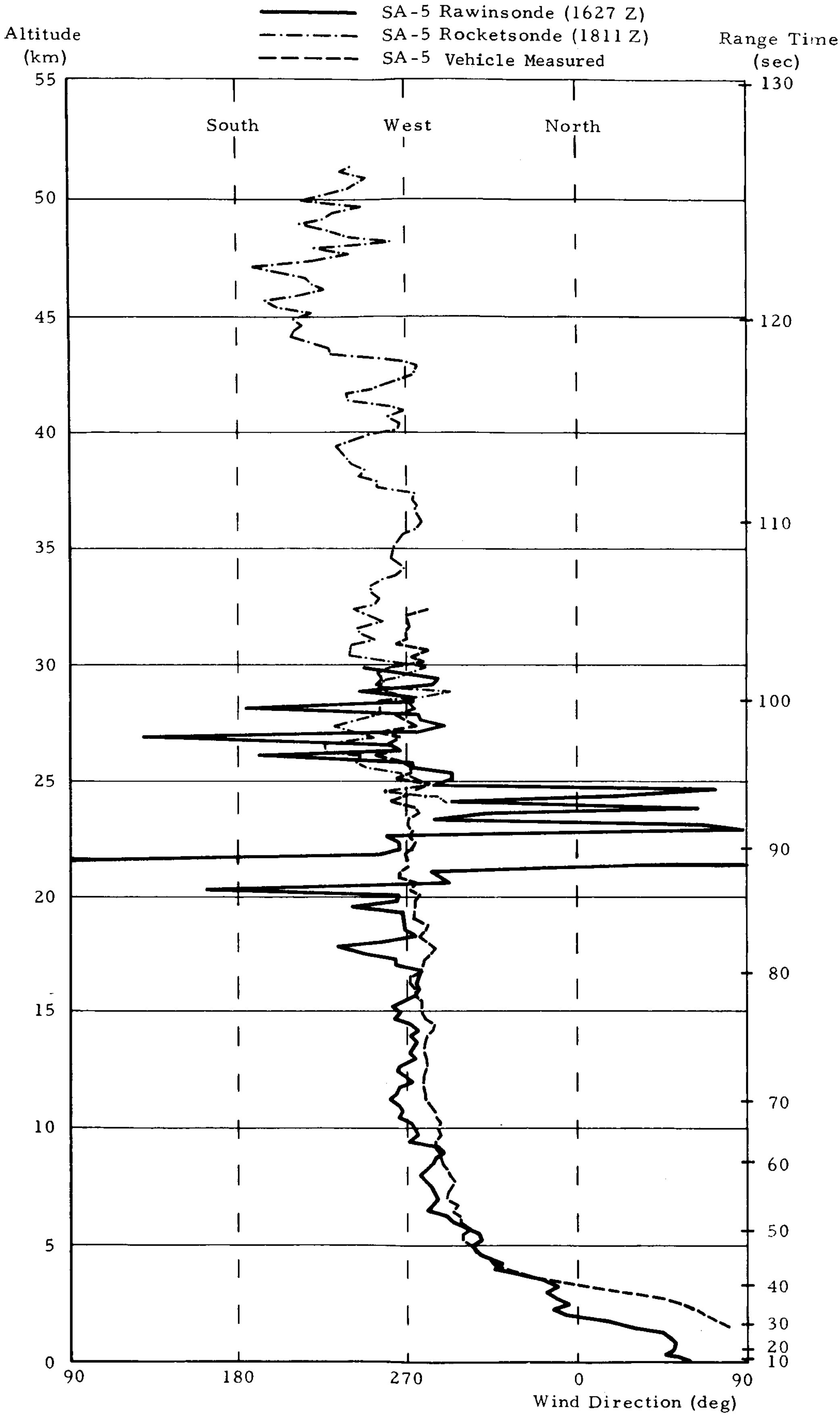


FIGURE 6. LAUNCH SITE WIND DIRECTION

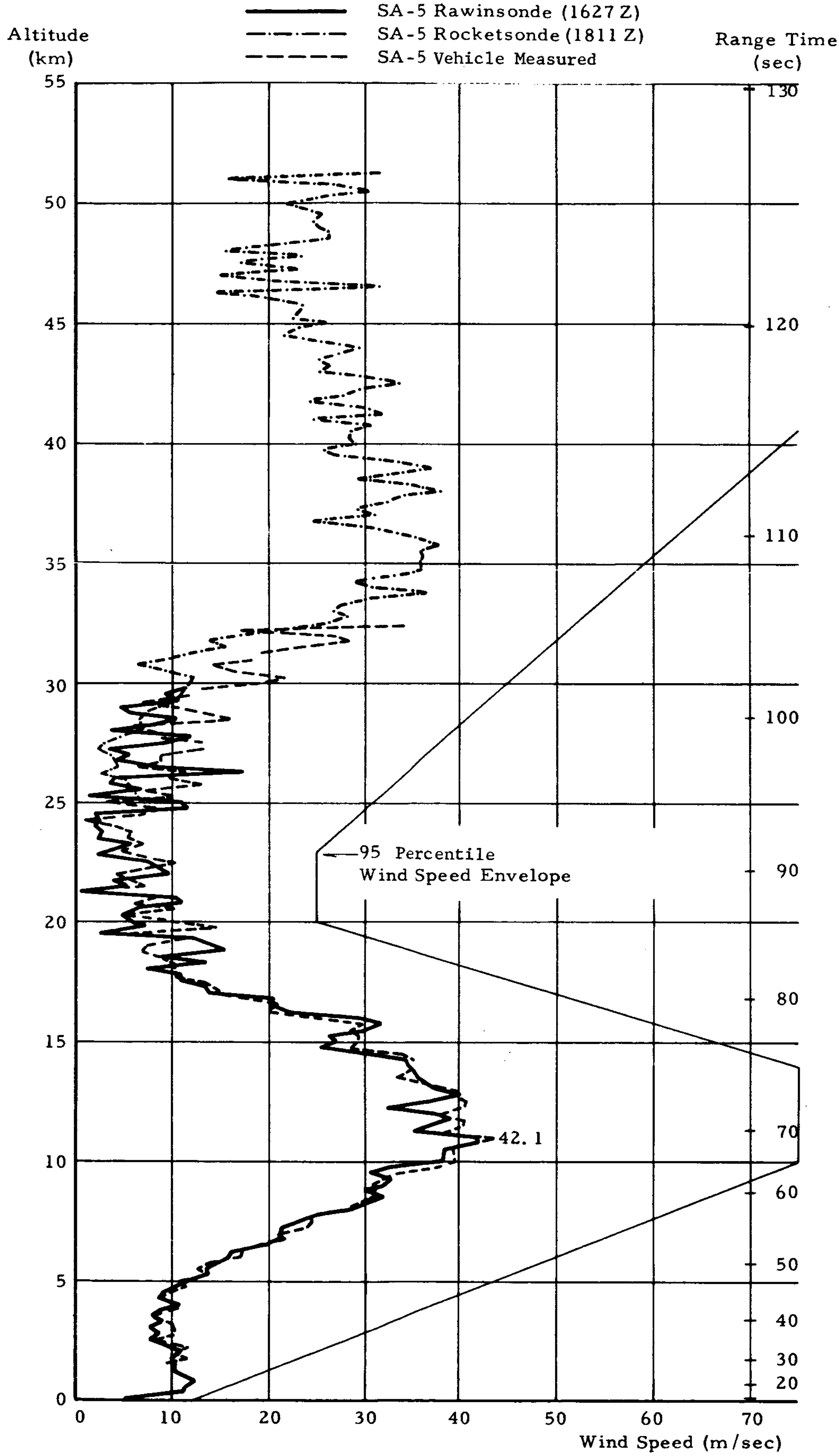


FIGURE 7. LAUNCH SITE WIND SPEED

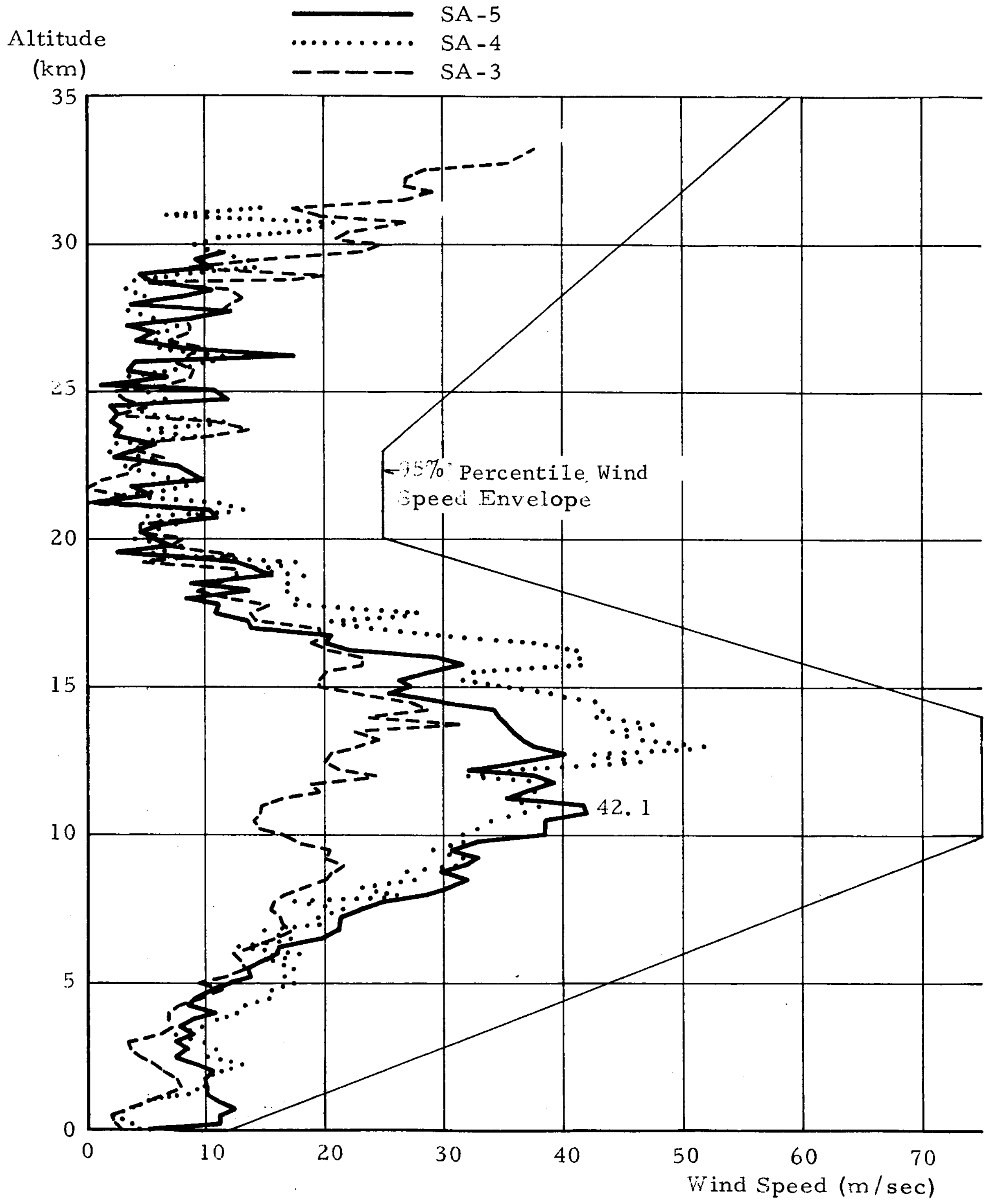


FIGURE 8. LAUNCH TIME WIND SPEED COMPARISON (RAWINSONDE), SA-3, SA-4, AND SA-5

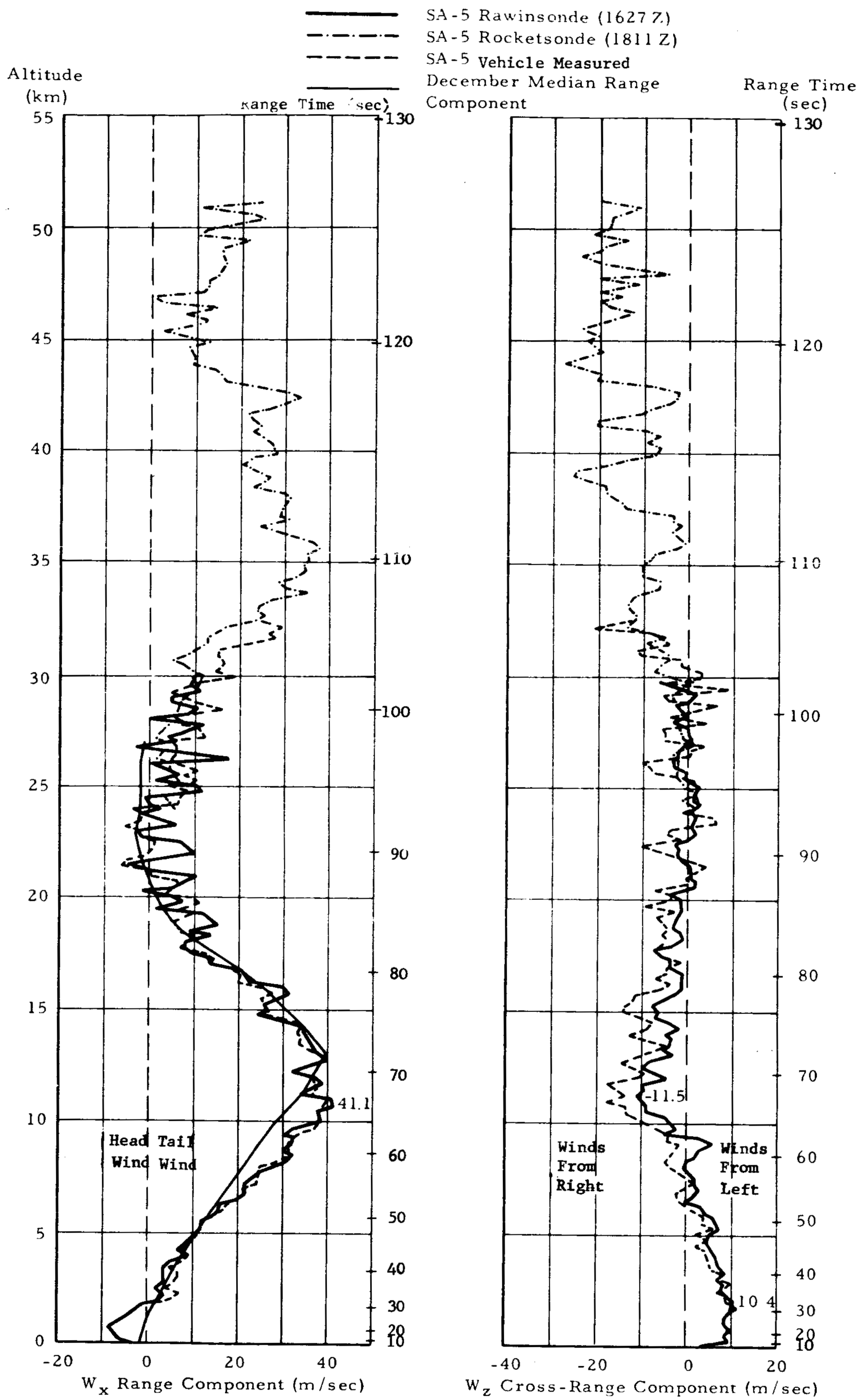


FIGURE 9. LAUNCH TIME WIND COMPONENTS

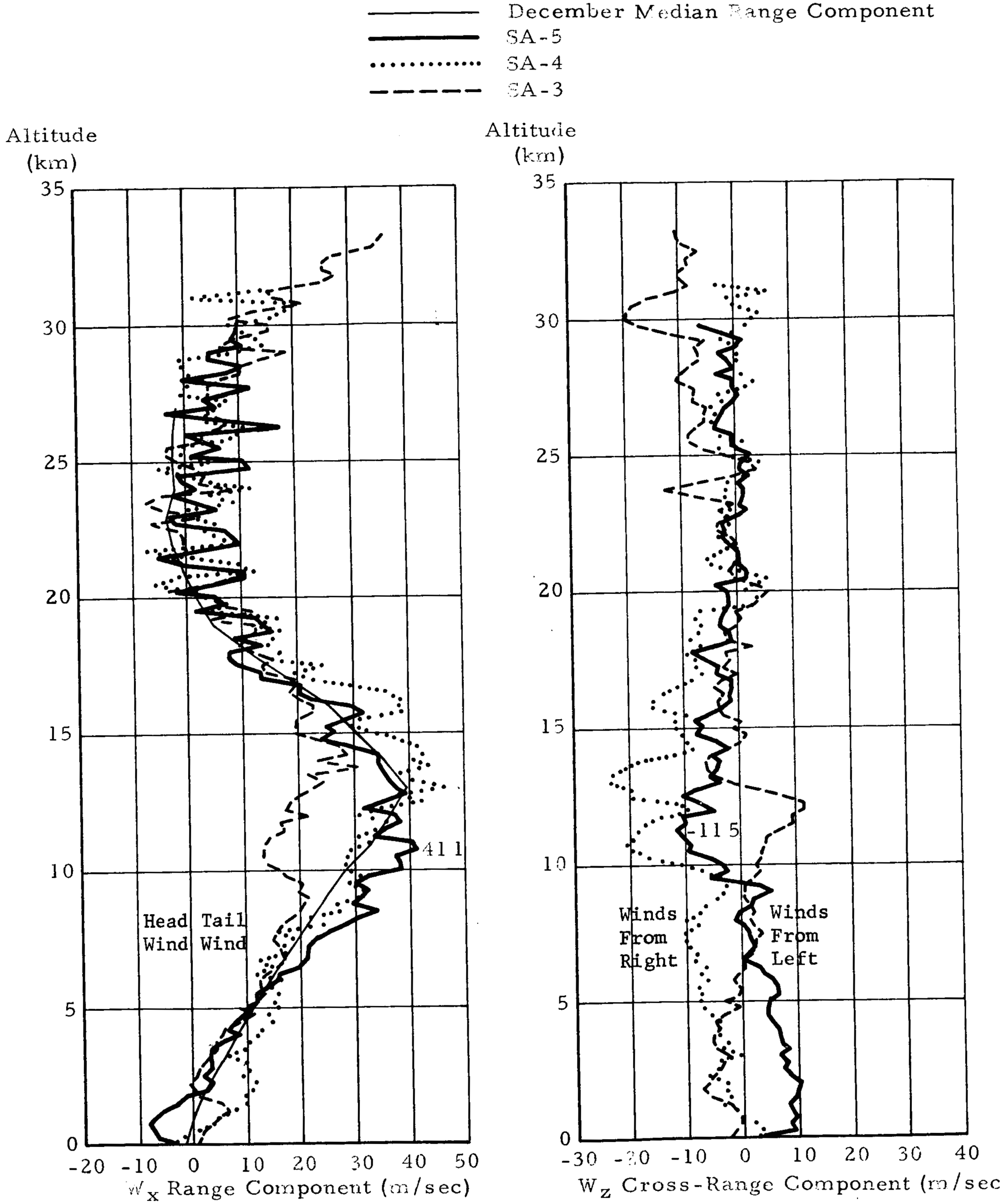


FIGURE 10. LAUNCH TIME WIND COMPONENT COMPARISON (RAWINSONDE), SA-3, SA-4, AND SA-5

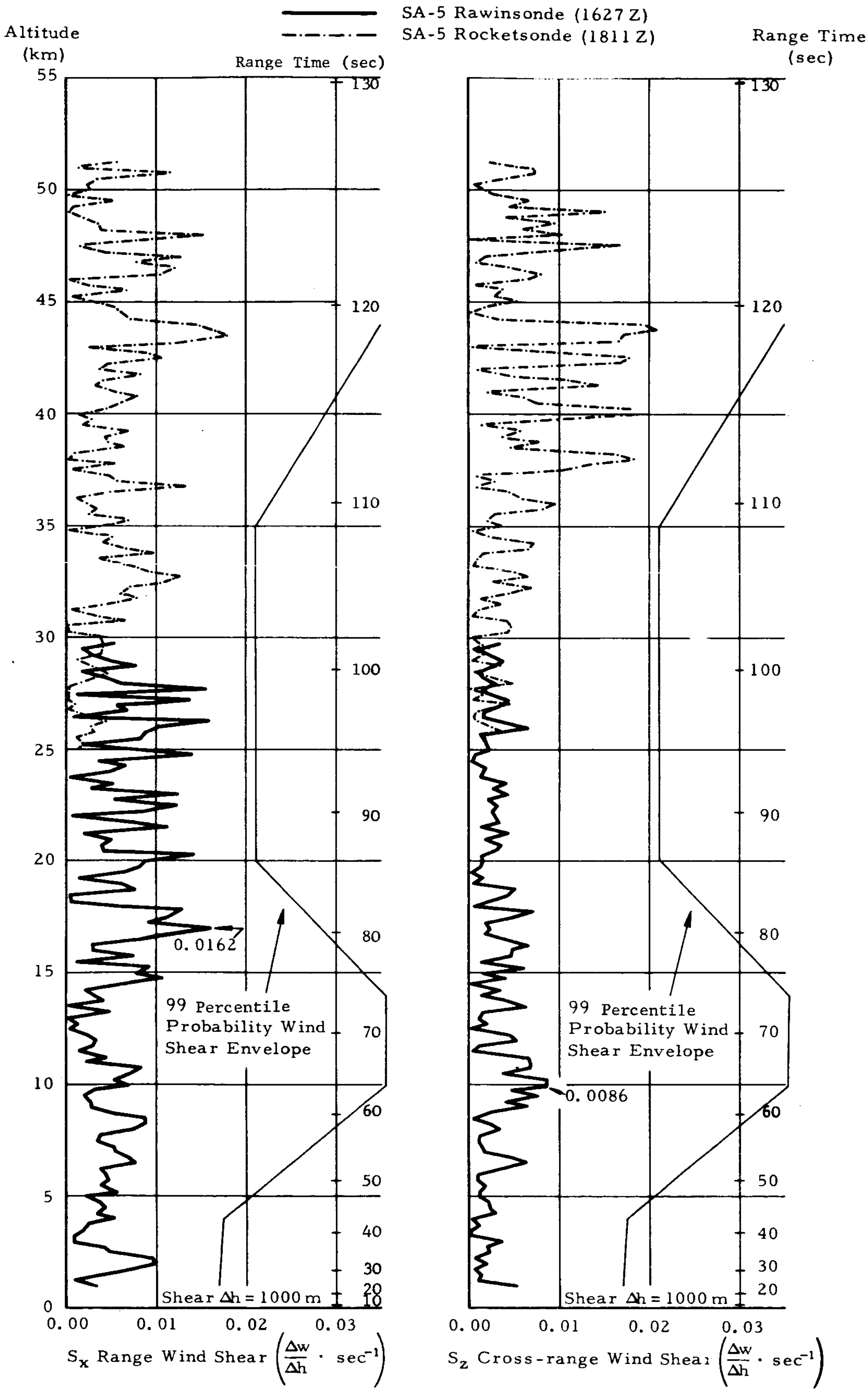


FIGURE 11. RANGE (S_X) AND CROSS-RANGE (S_Z) WIND SHEAR COMPONENTS (Δh, 1000 m)

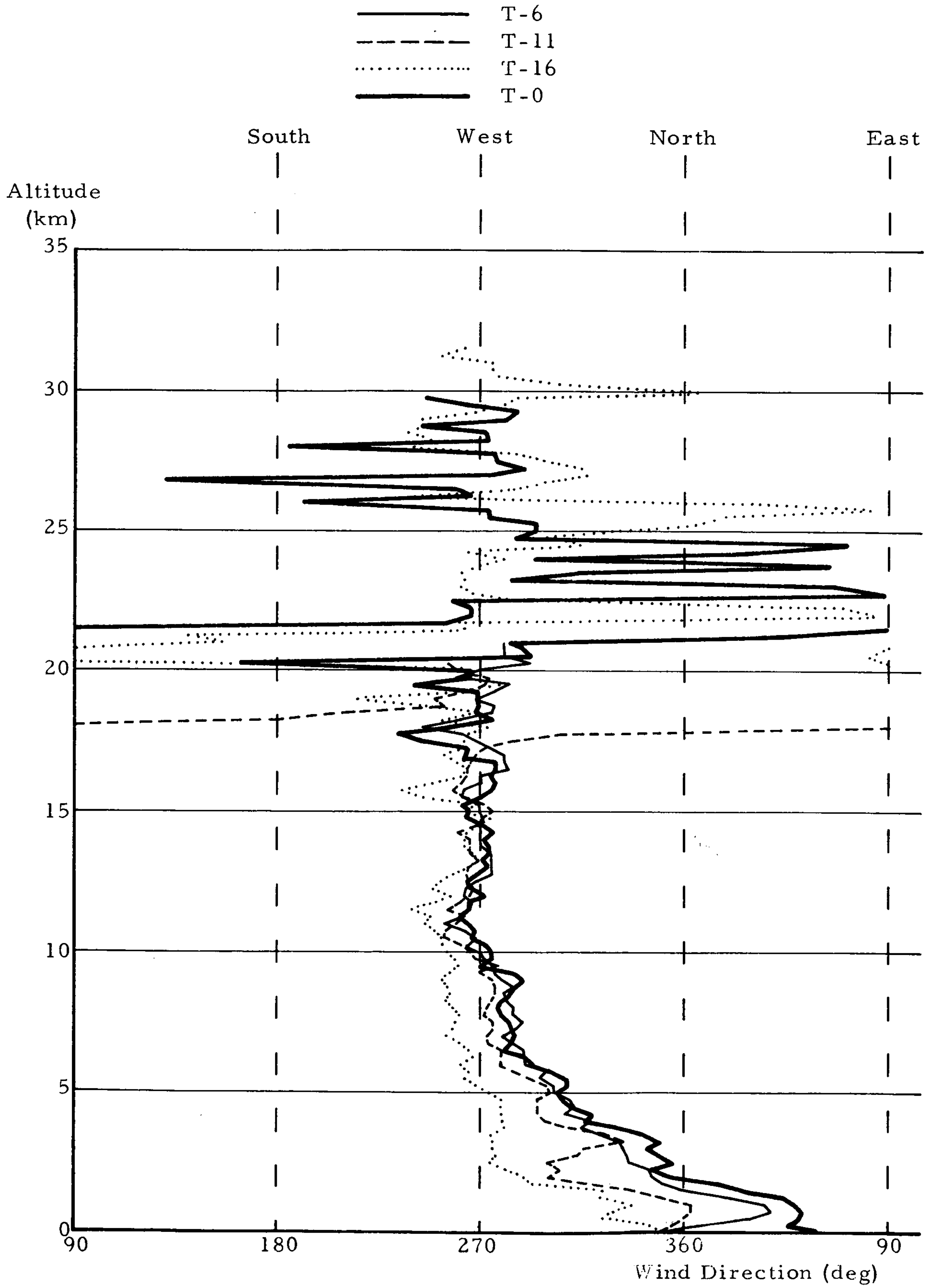


FIGURE 12. LAUNCH SITE WIND DIRECTION TIME COMPARISON (RAWINSONDE)

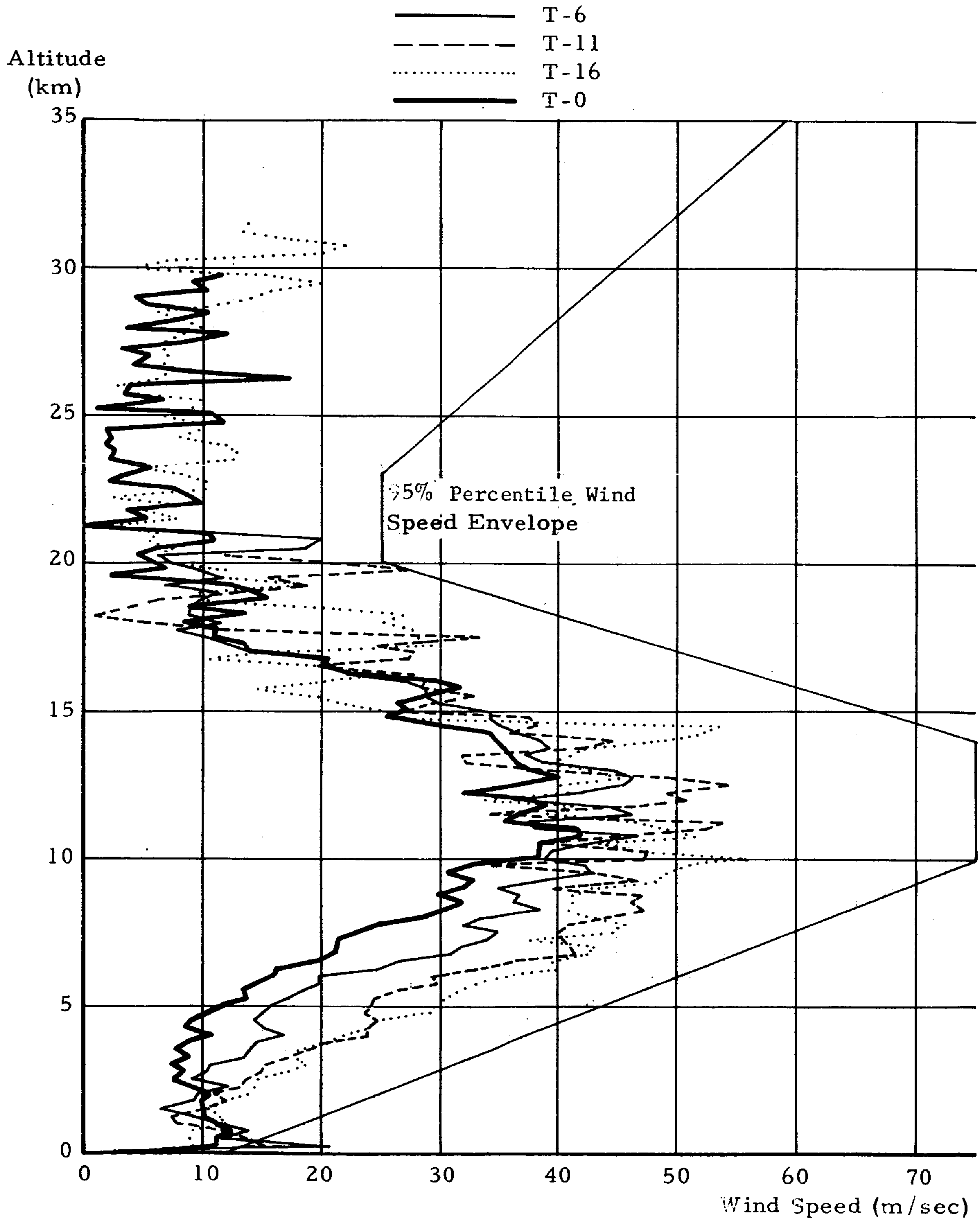


FIGURE 13. LAUNCH SITE WIND SPEED TIME COMPARISON (RAWINSONDE)

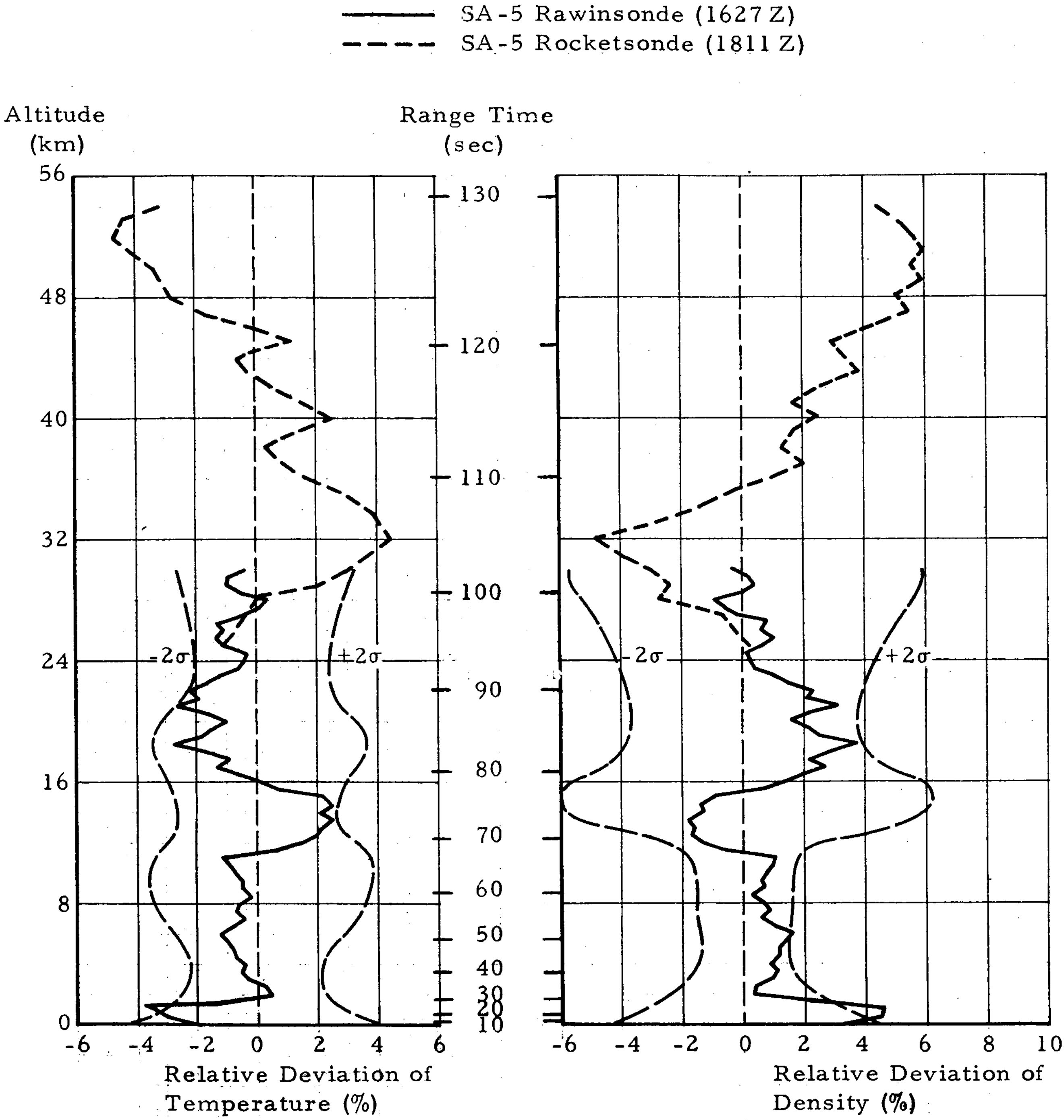


FIGURE 14. RELATIVE DEVIATION OF SA-5 TEMPERATURE AND DENSITY FROM PAFB REFERENCE ATMOSPHERE

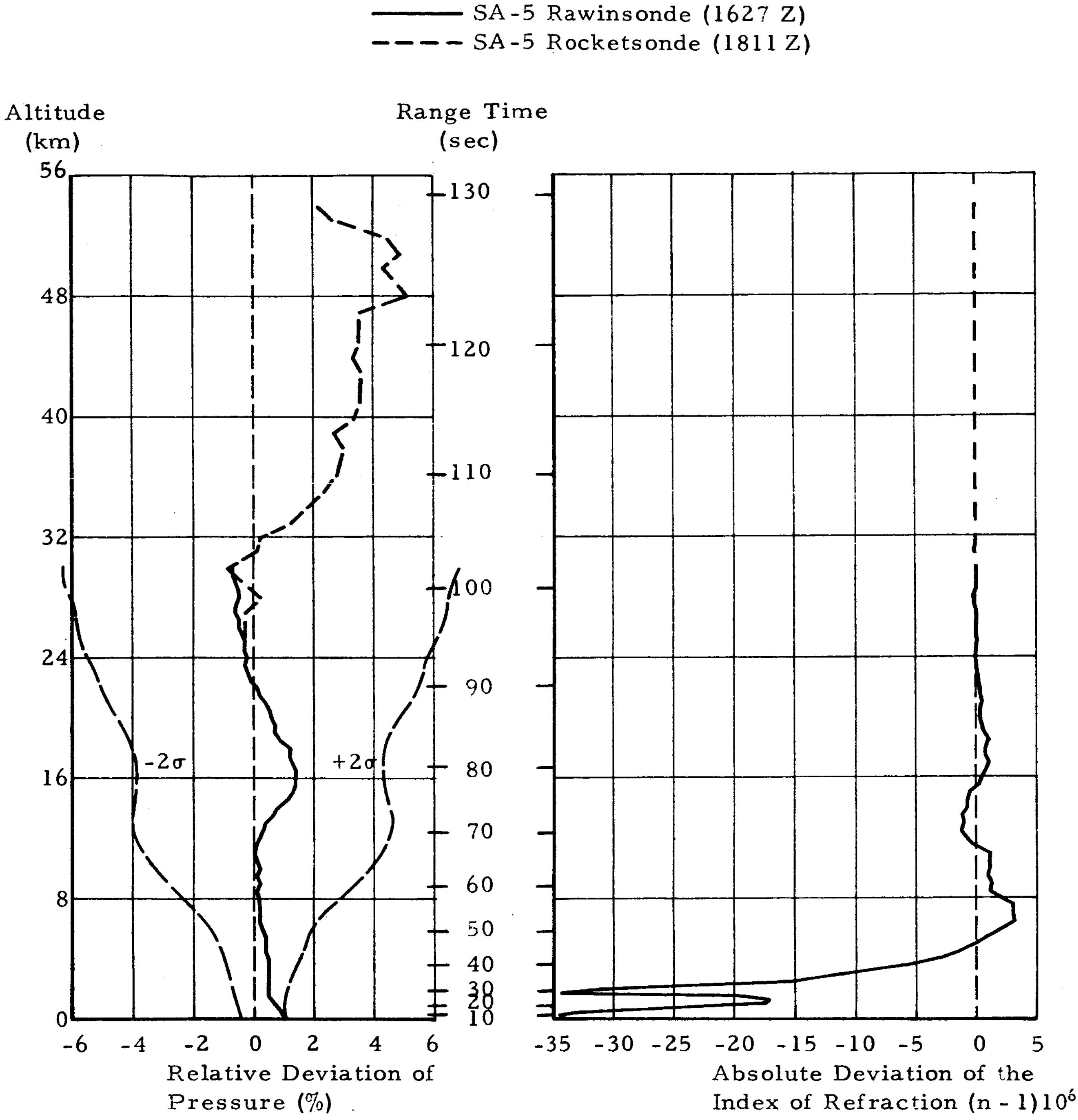


FIGURE 15. RELATIVE DEVIATION OF PRESSURE AND ABSOLUTE DEVIATION OF THE INDEX OF REFRACTION FROM THE PAFB REFERENCE ATMOSPHERE

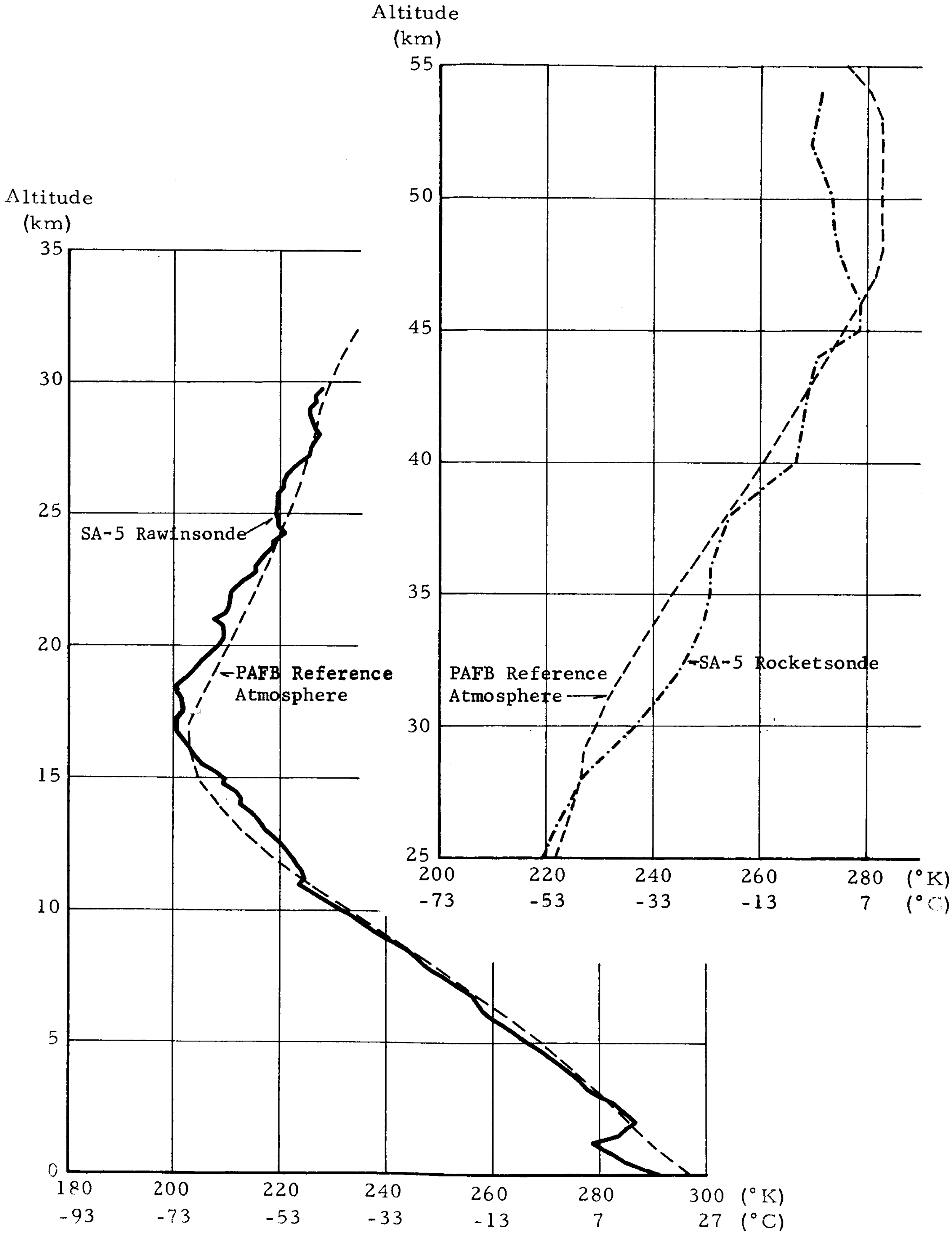


FIGURE 16. LAUNCH SITE AMBIENT TEMPERATURE

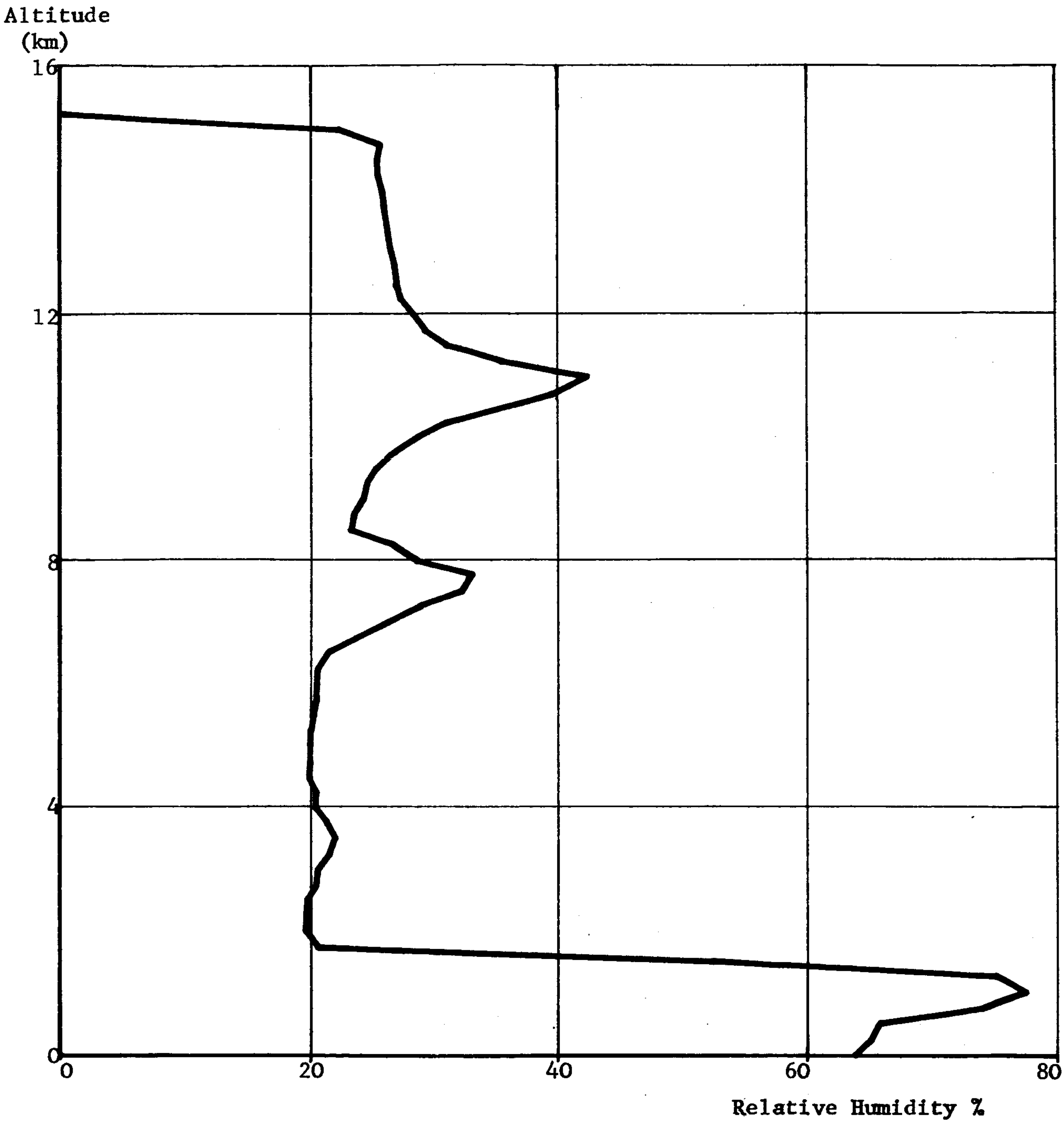


FIGURE 17. LAUNCH SITE RELATIVE HUMIDITY

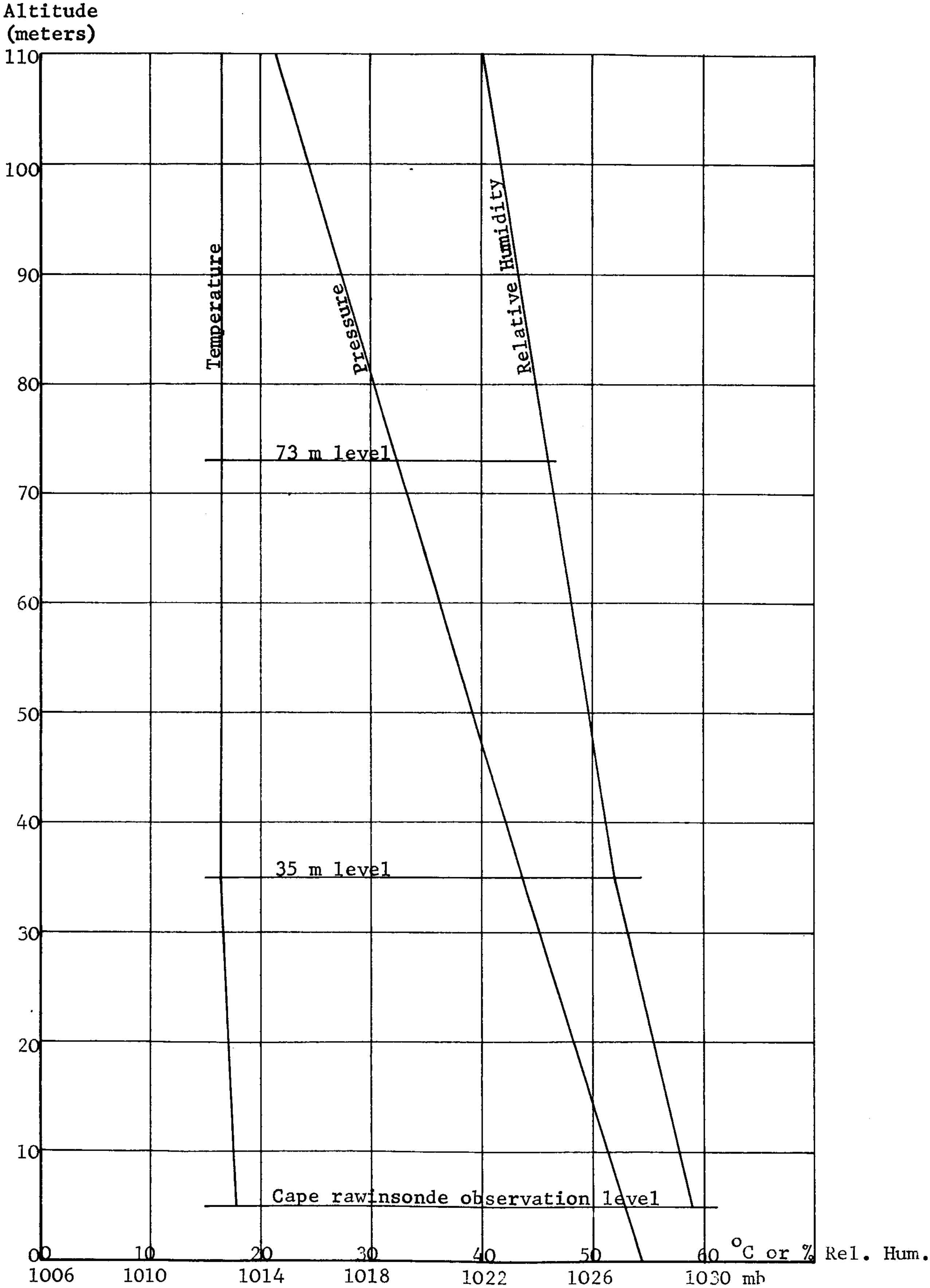


FIGURE 18. LOW LEVEL TEMPERATURE, PRESSURE AND RELATIVE HUMIDITY FOR THE SA-5 LAUNCH

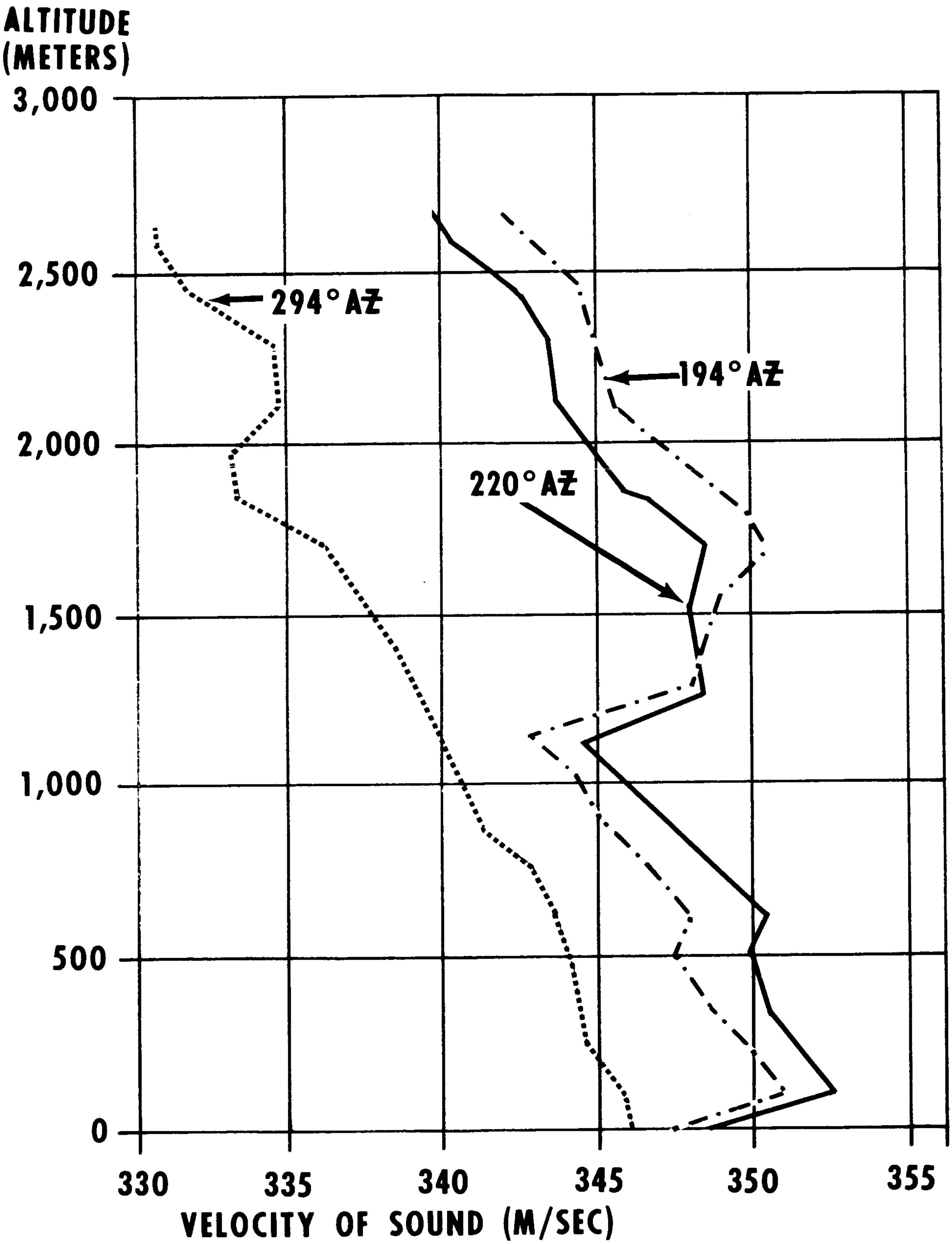


FIGURE 19. SA-5 VELOCITY OF SOUND PROFILES

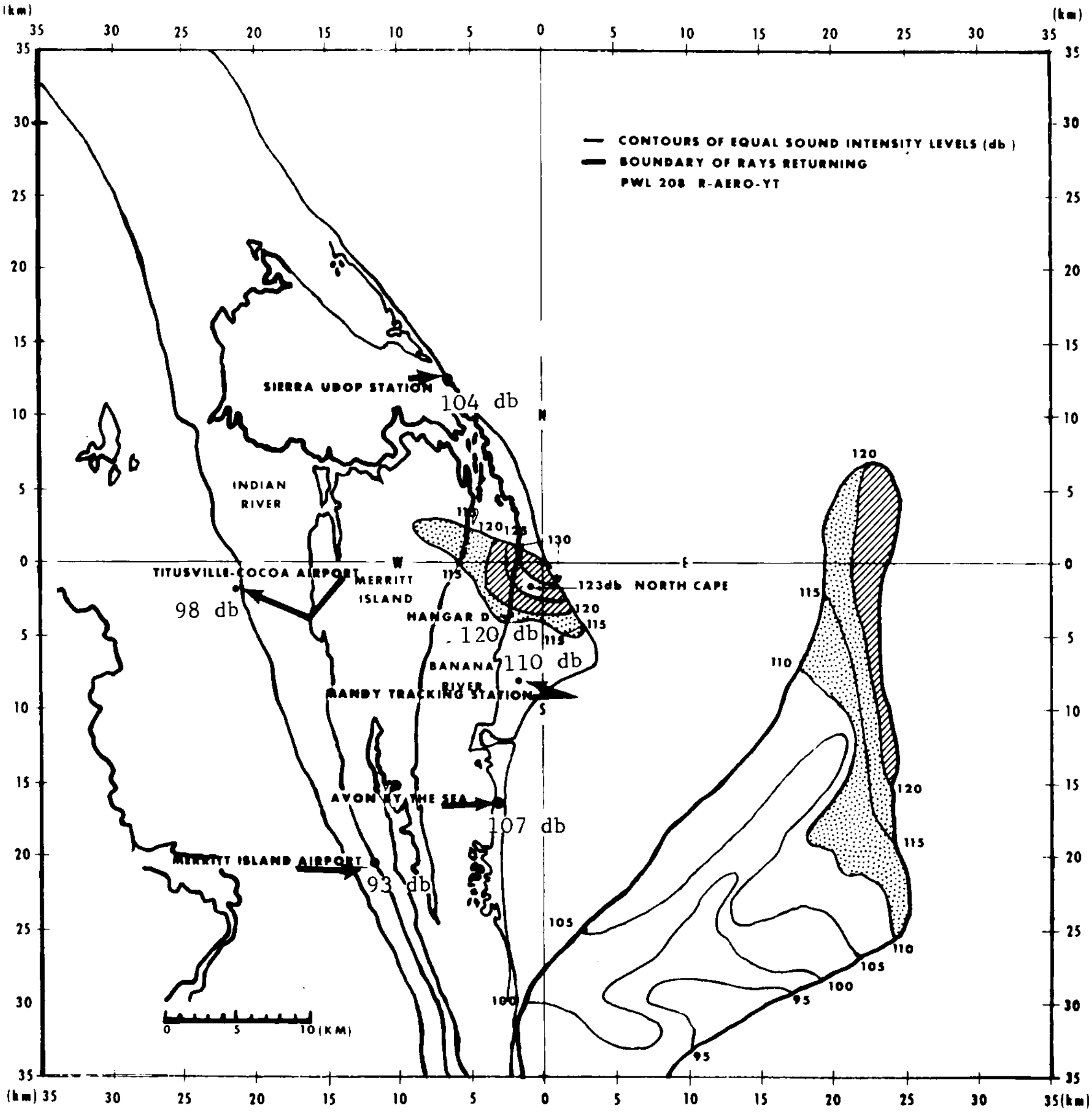


FIGURE 20. CALCULATED SOUND INTENSITY LEVELS FOR SA-5

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April 30, 1964 APPROVAL NASA TM X- 53040

ATMOSPHERIC ENVIRONMENT FOR SATURN (SA-5) FLIGHT TEST

By J. W. Smith

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